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PICKERING ROUND WHITEFISH SAMPLING, SPRING, 1989

Report No 90-145-K

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ABSTRACT

Two types of larval emergence traps were utilized to assess the occurrence of round whitefish larvae in the vicinity of the thermal discharge of Pickering NGS "B". A total of 29 traps were deployed between March 13 and May 2, 1989 on a main transect, extending from the 4 to 9 m depth contours (21 traps), and on two secondary transects (4 each), perpendicular to the main transect. Both cross transects were at approximately the 5 m depth, as a result of an offshore topographical feature. Two round whitefish larvae were collected during the course of the study (one in each trap type). The first larva was collected on March 31 from trap 5, which was on the main transect at 4.5 m depth, while the second larva was collected on April 11 from trap 29, which was on the outer cross transect at the 5 m depth. Comparison of these results with previous field studies (1984 - 1988) indicates that these larvae were collected approximately three weeks and one week earlier, respectively, than larvae collected from areas not subjected to thermal increases (Whitby and Darlington). These dates are also within the time span during which round whitefish larvae were collected from the Pickering NGS intake in 1988.

job	file	date	report no.
34-122-592	837.321 PIC	June 12, 1990	90-145-K

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EXECUTIVE SUMMARY

PICKERING ROUND WHITEFISH SAMPLING, SPRING, 1989

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Survey Technician
Biological Research Section
Chemical Research Department

Round whitefish populations in the vicinity of the Pickering NGS have been studied extensively in the course of preoperational, interim and postoperational environmental studies conducted to obtain permission to draw cooling water from Lake Ontario for Pickering NGS "B". In addition, laboratory and field studies have investigated the effects of constant and intermittent temperature increases during the winter egg incubation period of this fall spawning species. These studies have identified an area close to the discharge as being a likely spawning area, while entrainment studies in 1988 collected advance hatch larvae from the common intake. Incubation experiments, both in situ and in the laboratory, have shown that the thermal regime present in the nearshore discharge area is sufficient to advance egg hatch by as much as 4-5 weeks. The objectives of the present study were to assess the feasibility of two types of larval emergence traps for round whitefish collection, and evaluate the timing of larval emergence with respect to predictive models and the timing of round whitefish larval entrainment at Pickering in 1988.

Twenty-nine emergent traps were deployed along a 700 m main transect, extending from the 4 to 9 m depth contour, and along two cross transects, both at approximately the 5 m depth. Cross transects were spaced at one- and two-third intervals along the length of the main transect. The similarity in the depth of the cross transects was the result of an offshore topographical feature. Traps were deployed 35 m apart and 10 m to the east of the anchor buoy at each location. They were rigged in such a manner that they could be retrieved, serviced and redeployed from the surface without the aid of divers. Installation of the traps took place between March 13 and March 20, 1989. Traps were serviced at approximately 5-day intervals, with final retrieval taking place on May 2, 1989. Continuously recording (hourly) thermographs were placed on the bottom inshore and offshore of the two cross transects.

Two larval round whitefish, as well as a large number of sculpins (123) and a single logperch, were taken from the emergent traps during the course of the study. The first larva (13.9 mm in length) was collected on March 31 from trap #5, while the second larva (13.1 mm in length) was taken from trap #29 on April 11. Both larvae were alive at the time of collection, yolk sacs were almost completely absorbed and they swam freely around the collection chamber. One larva was collected from each of the two types of emergent traps being used. No round whitefish larvae were found in the stomachs of the 106 sculpins examined.

job	file	date	report no.
34-122-592	837.321 PIC	June 12, 1990	90-145-K

Substrate at each trap location was surveyed by SCUBA diver during the final week of the study, and a number of locations (including 5 and 29) were videotaped. These observations indicate that glacial sediment is the predominant substrate type, with cobble and boulder being the dominant particle sizes throughout the study area. Location #1 was the notable exception, with approximately 95% sand cover.

Comparison of our results with those of previous studies indicates good agreement. Timing of larval collection during this study was within the time frame that round whitefish larvae were collected during the 1988 entrainment study (March 16 to April 29). Although continuous temperature records are unavailable, due to flooding of the recording instruments, good approximations of temperature structure within the thermal plume are available from previous studies and from computer modelling. When these are applied to the two locations where larvae were collected, good agreement exists between our results and predictive models based on actual egg incubation data. This study then further documents advance hatch of round whitefish larvae at Pickering NGS and identifies a spawning area close to the Pickering NGS "B" discharge. The extent of the spawning area, and the density of emerging larvae could not be determined from this study.

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PICKERING ROUND WHITEFISH SAMPLING, SPRING, 1989

L.P. King

1.0 INTRODUCTION

Round whitefish populations between Pickering NGS and Whitby have been studied extensively since 1976 (Haymes and Kolenosky, 1984) with increasing emphasis placed on determining the extent of spawning populations and the effects of the thermal discharge on spawning behaviour and subsequent development of eggs and larvae. Incubation experiments, conducted under laboratory and field conditions, indicate that hatch advancement is a result of extended thermal plume exposure (OHRD Report Nos 80-140-K, 83-351-K, and 87-181-K). The consequences of early hatch are asynchrony of larvae with food supplies (ie. plankton) required for initial development, resulting in decreased survival and ultimate population decrease (Greig et. al., 1986).

Netting studies conducted between 1986-1988 indicated that a large number of round whitefish are present at the 7 meter depth along the Pickering "B" discharge transect during the middle weeks of December (OHRD Report Nos 87-194-K, 88-261-K, and 89-149-K). Both ripe and spent individuals were collected during sampling in 1988 (to December 22), while ripe individuals were collected in 1986 and 1987. It is also interesting to note that this transect provided the second highest catch of round whitefish of 13 transects between Pickering and Port Hope during a netting study conducted in 1980. Thus it appears that this area has been utilized by spawning round whitefish historically, and that the aggregation at this site is not merely due to thermal attraction.

Entrainment sampling was conducted at Pickering NGS in 1988, commencing in mid-March. Round whitefish larvae were collected on the first day of sampling, and were present in samples until April 27, with a total of 16 larvae collected (OHRD Report No 89-295-K). Comparison of these results with previous field and laboratory studies (OHRD Report Nos 80-140-K, 87-181-K), indicate that larvae collected during March and early April were the result of hatch advancement due to thermal influences.

This report describes the use of two types of larval emergence traps for the collection of round whitefish larvae, and evaluates the timing of larval emergence with respect to predictive models and the timing of round whitefish larval entrainment at Pickering in 1988.

2.0 MATERIALS AND METHODS

Larval emergence traps were placed at 35 m intervals along a 700 m main transect line (Pickering "B" discharge transect) extending from the 4 to 9 m depth contour and along two short transect lines, each perpendicular to the main transect at one and two-third intervals along the main transect (Figure 1). Location of individual traps (latitude/longitude coordinates) and depth of deployment are presented in Appendix 1.

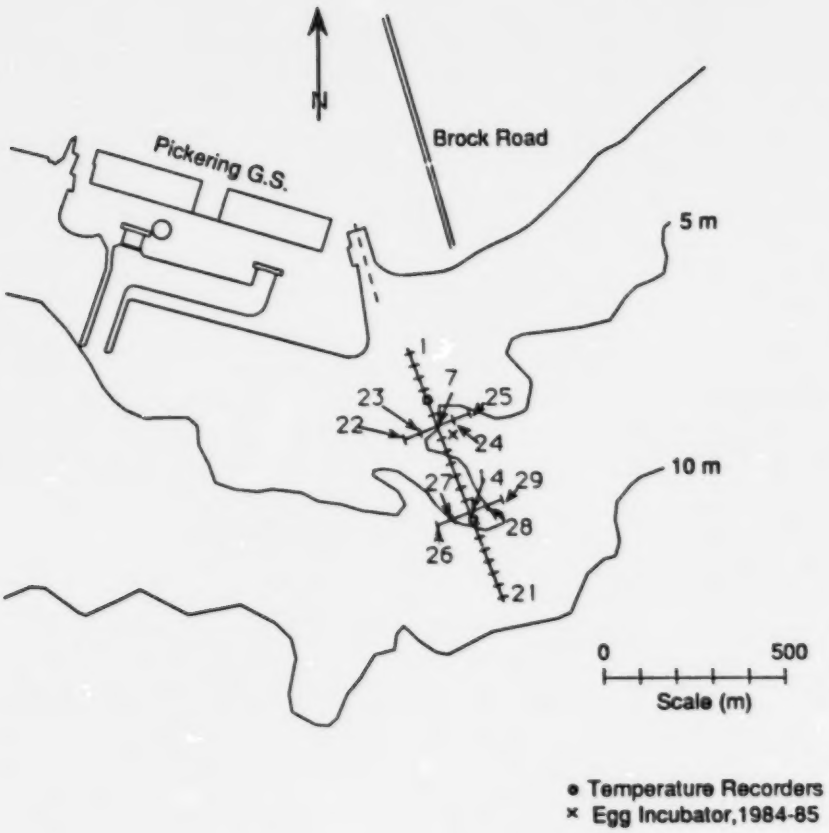

FIGURE 1

LOCATION OF MAIN AND SECONDARY TRANSECTS DURING LARVAL ROUND WHITEFISH SAMPLING, 1989

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Traps on the main transect line were deployed on March 13, while those on the cross-transects were deployed on March 20. Each trap was attached to an anchor and float line assembly as shown in Figure 2. This assembly allowed the traps to be pulled, serviced and redeployed from the surface. The drawback of the system was that calm (less than 30 cm wave heights) lake conditions were required for servicing, as traps had to be inverted prior to removal from the water. The distance between the trap and the anchor was set at 10 m and traps were redeployed as close as possible to the original location (due east of anchor) on subsequent sampling occasions.

The larval emergence trap was initially designed by Collins (1973) to collect emergent kokanee salmon and lake whitefish fry and has recently been modified to collect lake trout fry by Marsden et al.(1988). Our samplers (Figure 3) were enlarged from the 0.5 m square utilized by Marsden et al. to a 0.75 m square. The outer frame of each sampler was constructed of 3.8 cm steel angle iron to which #14 galvanized steel mesh (approximately 1300 micron openings) was attached.

The collection chamber of the sampler consisted of a one litre polymethylpentene wide-mouth jar which was inverted and attached to a plywood plate at the apex of the four sides. A plastic powder funnel was inserted through an opening drilled in the jar lid, such that it was retained between the jar lid and the plywood plate. The opening from the sampler body to the collection chamber decreased in size from 8.9 cm, at the apex of the four sides, to 1.5 cm, at the entrance to the collection chamber.

Traps were individually deployed at each sampling location as shown in Figure 2. During servicing, the trap was lifted from the bottom by the line attached between the trap and the surface float, and inverted prior to being brought aboard the sampling vessel. This ensured that the sample in the collection chamber was retained while being brought on board. The collection chamber could then be quickly unscrewed from the lid, emptied, and reattached, while the vessel maintained position at the anchor buoy. The trap was then returned to the water, while the sampling vessel moved to a point approximately 10 m due east of the anchor buoy, at which time the trap was lowered to the bottom.

In addition, 8 larval emergence traps, of a different design, were obtained on loan from the Lake Huron Fisheries Assessment Unit (MNR, Owen Sound) (Figure 3). These traps consisted of a short 0.8 m diameter conical net (1.6 mm mesh) which was supported between a ring of 6.4 mm steel rod and a wooden upper platform. The wooden platform also provided a point of attachment for two loops of surgical tubing which secured the collection chamber (2.0 L glass jar) to the sampler. A funnel, constructed of wire screening, served to retain larvae within the collection chamber.

All traps were installed and serviced in the same manner and schedule. They were serviced at 5-day intervals (weather permitting) and samples were preserved in 5% formaldehyde solution, with subsequent transfer of larvae to Davidson's B solution. Final retrieval of traps took place on May 2.

Thermographs were installed along the main transect line on March 17 between traps 4-5, and 14-15, in 4.5 and 5.5 m of water, respectively. A SCUBA survey of substrate along the sampling transect was conducted on April 29 and May 1. Environmental parameters (temperature, sea state, wind direction and speed) were recorded during each servicing interval.

3.0 RESULTS

3.1 Larval Fish Catch

A listing of service dates and catch results are presented in Table 1 and Appendix 2. Two round whitefish larvae were collected in the traps during the course of the study. The first larva was

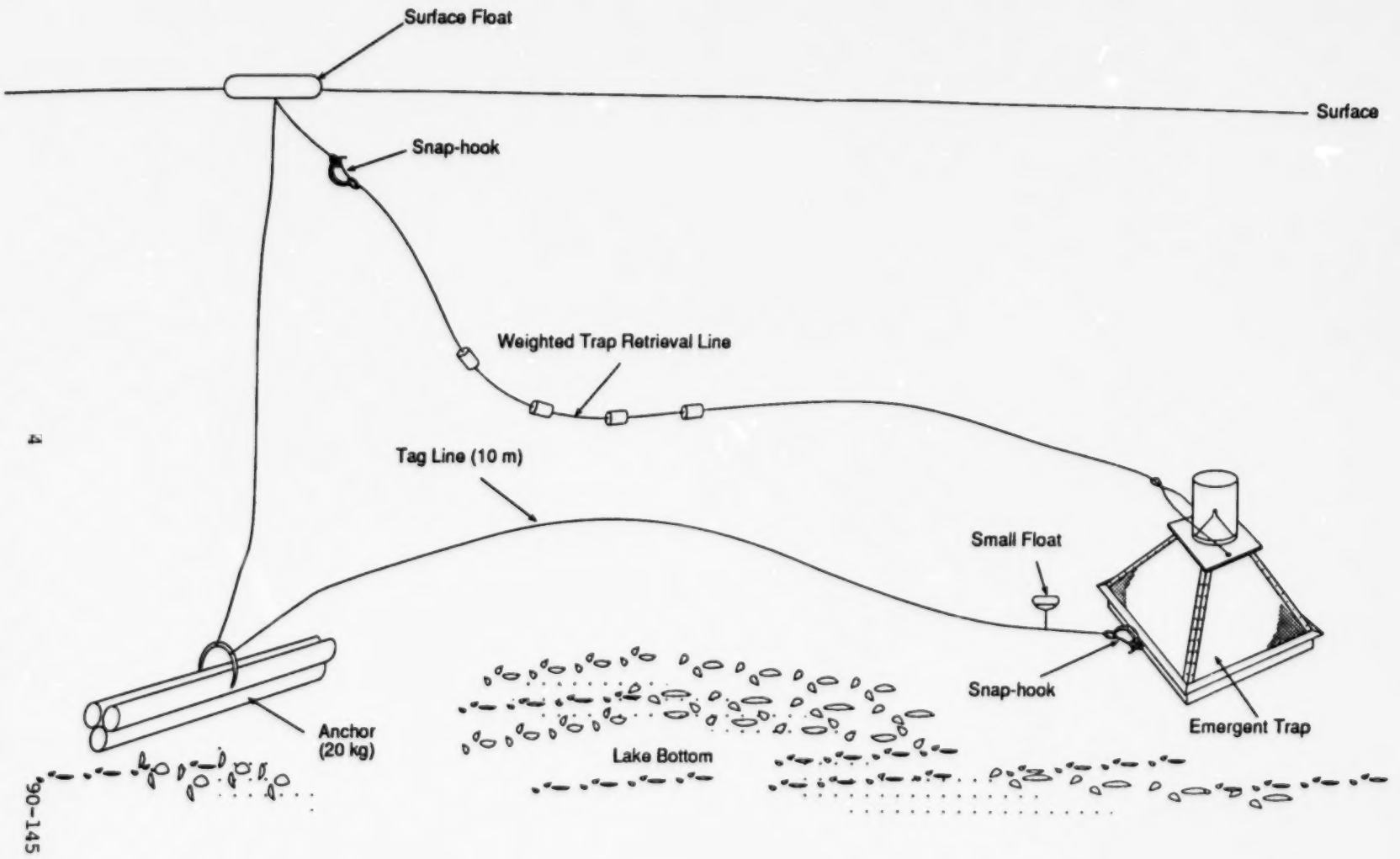

FIGURE 2

METHOD OF DEPLOYMENT OF LARVAL EMERGENCE TRAPS
PICKERING, 1989

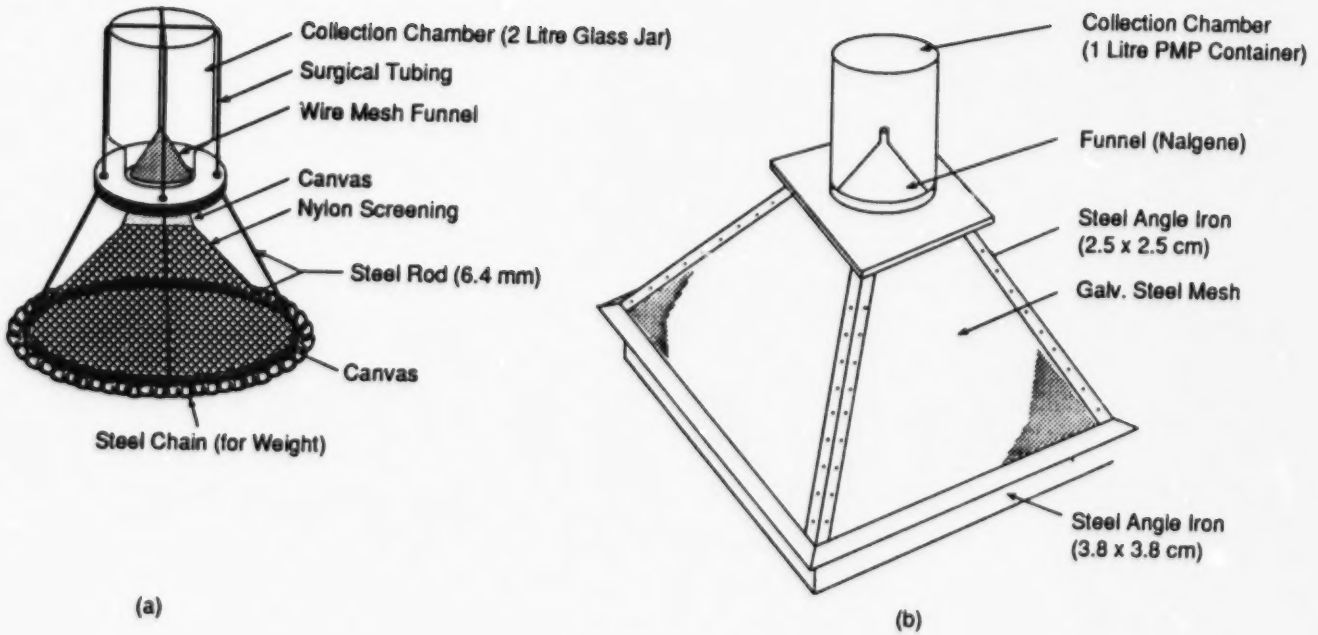

FIGURE 3

LARVAL EMERGENCE TRAPS EMPLOYED DURING ROUND WHITEFISH STUDY, SPRING 1989
(a) MNR TRAP (b) OHRD TRAP

TABLE 1

FISH CATCH IN EMERGENT TRAPS PICKERING NGS, 1989

DATE	ROUND WHITEFISH (LARVA)	SCULPINS (ADULT AND JUVENILES)	LOGPERCH ADULT
March 17		2	
March 22		9	
March 31	1	19	1
April 5		4	
April 7		8	
April 11	1	14	
April 17		20	
April 21		20	
April 26		14	
May 2		13	
Total	2	123	1

collected from trap #5 on March 31, while the second larva was collected from trap #29 on April 11. Previous service dates for these traps were March 22 and April 7, respectively. Both larvae were alive at the time of collection and were 13.9 and 13.1 mm in length, respectively. Yolk sacs were almost completely absorbed and they swam freely in the collection chamber. Sculpins were also a major component of the fish catch. One hundred and twenty three individuals were collected, with a maximum catch of 20 on any sampling day. Stomachs were examined from 106 sculpins, but no round whitefish larvae were found. One logperch was also collected in an emergence trap.

3.2 Temperature

Bottom temperatures recorded during servicing of emergent traps are recorded in Table 2. Temperatures during the three service dates at trap #5, up to and including the date of larval capture, were 3.4, 4.5 and 4.1°C. Bottom temperatures during service intervals at trap #29, were 6.0, 3.4, 7.7 and 6.6°C. Unfortunately, thermographs (Hydrolab Series 2000 programmable datasonde) deployed between traps 4-5 and 14-15 flooded, resulting in the loss of hourly temperature measurements for the duration of the study.

3.3 Substrate

Results of substrate surveys are listed in Appendix 3. A number of locations were videotaped as well, including locations 5 and 29. Examination of these results indicates that substrate along the main transect and cross-transects consists of varying percentages of boulder, cobble, gravel and sand. This composition of particles is indicative of an eroded glacial till, where fine materials

TABLE 2

BOTTOM TEMPERATURES (°C) PRESENT AT EMERGENT TRAPS
DURING SAMPLING SCHEDULE, 1989

TRAP NUMBER	MARCH 17	MARCH 22	MARCH 31	APRIL 5	APRIL 7	APRIL 11	APRIL 17	APRIL 21	APRIL 26	MAY 2
1	3.6	5.3	5.0	-	7.4	6.4	6.3	6.9	7.9	7.5
2	5.6	4.8	4.6	-	7.4	6.4	6.5	6.9	8.1	5.6
3	5.2	4.5	4.4	-	6.6	6.7	6.4	6.8	8.6	5.7
4	4.3	4.5	4.3	-	9.8	7.9	6.3	6.7	8.8	5.7
5	3.4	4.5	4.1	-	10.7	9.8	6.2	7.2	9.1	5.7
6	3.1	4.7	4.1	-	8.5	8.7	6.3	8.3	9.1	5.8
7	3.1	5.2	4.0	-	8.5	8.6	-	-	-	-
8	3.2	6.0	4.0	-	7.8	7.1	5.7	9.3	9.1	-
9	3.1	5.0	3.9	-	8.1	6.6	5.6	9.3	9.1	6.8
10	2.9	4.0	3.8	-	8.5	6.8	5.6	9.4	9.1	6.5
11	2.4	4.4	3.7	-	-	-	-	-	-	-
12	2.6	5.0	3.6	-	7.6	5.9	5.7	7.1	9.1	5.6
13	2.8	4.6	3.6	5.8	7.3	5.8	5.7	7.0	9.0	5.5
14	5.4	4.0	3.5	5.7	7.1	5.9	5.8	6.7	9.1	5.2
15	3.2	2.5	3.4	5.6	6.2	5.6	5.6	6.3	8.7	5.1
16	4.6	1.5	3.4	5.6	5.9	5.3	5.7	6.3	8.6	4.9
17	5.0	0.5	3.3	5.4	5.6	5.1	5.7	6.3	8.8	4.9
18	6.0	1.1	3.3	5.2	5.4	5.1	5.5	6.2	8.6	4.9
19	5.5	1.5	3.3	4.5	5.0	4.9	5.6	6.0	8.0	4.8
20	4.7	1.5	3.3	4.4	4.9	4.5	5.4	5.9	8.1	4.7
21	4.6	1.5	3.3	4.5	4.9	4.5	5.4	5.7	8.0	4.7
22		3.5	5.1	-	8.5	5.8	6.6	-	-	-
23		5.2	3.7	-	8.1	8.7	-	-	-	-
24		10.0	3.7	-	8.9	8.2	6.4	6.8	9.1	7.1
25		5.0	3.7	-	8.5	6.7	6.3	6.5	9.1	5.4
26		1.5	3.4	-	6.9	5.1	6.7	-	-	-
27		2.0	3.4	-	7.2	5.2	6.6	6.3	8.8	5.7
28		5.0	3.4	-	7.2	6.3	5.7	6.8	9.1	7.1
29		6.0	3.4	-	7.7	6.6	5.6	6.8	8.9	7.9

- = NO SAMPLE

(clays and sand) have been suspended and transported from the immediate area by wave and current action. Large particles (boulder, cobble and gravel), which are more resistant to movement, are left on the surface in similar proportions to which they were embedded in the glacial medium. Cobble is the predominant substrate particle present along the main transect and along the cross transects with the exception of locations 1, 28 and 29. Sand is the predominant substrate at location 1, while boulders were predominant at locations 28 and 29.

Cladophora cover was present on all larger particles in the study area, with strands to approximately 10 cm in length inshore of the 5 m depth contour. Examination of the substrate video also revealed that samplers were not always in complete contact with the bottom. In a number of cases, a corner or portion of the trap was resting on top of a large cobble or boulder, creating substantial gaps between the substrate and the trap framework.

4.0 DISCUSSION AND SUMMARY

Comparison of our results with those of previous studies indicates that larvae collected during this study had hatched in advance of the normal date. The earliest dates of capture of larval round whitefish in areas not subjected to thermal influences (Whitby and Darlington) ranged from April 19 to April 24 at Whitby in 1984-85 (OHRD Report No 87-181-K), and ranged from April 17 to April 23 at Darlington between 1985 and 1988 (OHRD Report No 90-18-K). All larvae obtained during these previous studies were collected with a benthic sled sampler. Larvae collected at Darlington over the four years of sampling ranged in length from 11.5 to 15 mm between April 17 and 26, with a mean length of 13 mm. Laboratory experiments indicate that larvae grow to 12-13 mm within a few days of hatch (OHRD Report No 88-334-K). Thus, the 13.9 mm larva captured on March 31 was collected approximately three weeks earlier than larvae which were collected from ambient temperature conditions, while the 13.1 mm larva collected on April 11 was approximately one week early. This seemingly large difference in hatch advancement between the two larvae can be readily explained by examining their proximity to the discharge and their consequent thermal exposure.

Despite the lack of continuous temperature records at these two locations, good approximations of thermal exposure can be obtained from other sources. Trap #5, from which the largest larva was collected, was located 400 meters offshore in an area that is almost continually exposed to the thermal discharge. Computer simulations of summer thermal plume extent and structure indicate that this area would experience a temperature rise of 5°C on the bottom during periods of easterly current and wind flow (wind 15 kw/h, current 11-18 cm/sec), and would also experience partial heating during periods of westerly flow (OH D&D Report No 85457). Temperatures recorded at trap #5 during the course of the study ranged from 1.2 degrees below to 5.8 degrees above the temperatures recorded at the trap furthest offshore (trap #21, 9 m depth). An egg incubation apparatus, used to assess the effects of the thermal effluent on the development and survival of round whitefish eggs, was placed approximately 100 m further offshore along the same transect line (adjacent trap #8) during winter 1984-85. Continuous temperature monitoring during that study, indicated that the eggs experienced an average temperature rise of 3°C, with weekly average fluctuations of 0.5 to 4.5°C above the assumed ambient (Thickson Point) (OH D&D Report No 86093, OHRD Report No 87-181-K).

Similar or higher temperature rises would exist at trap #5 during the winter of 1988-89. Three units were in operation at Pickering NGS "B" during winter 1984-85 compared to four units during winter 1988-89 (OHRD Report No 87-149-K, OH CPSD). Round whitefish eggs in the incubator hatched within 14-15 weeks in 1984-85, which was 4-5 weeks earlier than did those at a control location (Thickson Point). Assuming the spawning date of adult round whitefish in 1988 to be between December 15 and December 22, which are the dates when the largest number of ripe and spent individuals, respectively, were caught in the 7 m Pickering "B" discharge net; the time period between spawn and collection is approximately 15 weeks. However, this larva (13.9 mm) was not newly hatched, but had probably resided within the substrate for at least a week, absorbing the yolk-sac and gaining strength, prior to collection on March 31. Thus the actual hatch date for this larva would be approximately March 20-24, which compares well with the 1984-85 study.

Trap #29, which was located 700 m offshore and 70 m to the east of the main transect line, would also have experienced limited warming. Computer simulations indicate that this area would be exposed to bottom temperature increases of approximately 1°C during periods of easterly wind and current flow, but would remain unaffected during westerly flow (OH D&D Report No 85457). Current investigations conducted between 1979 and 1988 indicate that nearshore currents are predominantly alongshore (70-80% of the time), with a fairly consistent (1.4:1) ratio of east to west movement (OH D&D Report No 88797). Analysis of 1979-81 data on a seasonal basis, however, indicated that the predominance of easterly currents increased to 2.5 times the westerly component during the January to March period (OH D&D Report No 83208). Current investigations further inshore in 1987-88, at a point 600 m offshore near the Pickering NGS intake, indicated alongshore movement approximately 60% of the time during the January to March time period, with nearly 95% of this movement being in an easterly direction. The second dominant direction of movement was south-southeast, resulting in net transport to the east-southeast. The low westerly component of current direction was attributed to the location of the recording station between the discharges and near the cooling water intake of Pickering NGS A and B (OH D&D Report No 88797). Thus, it appears that water movement to the east predominates in the inshore area during the winter, resulting in frequent exposure of the trap at location #29 to heated effluent. Bottom temperatures recorded at this location during servicing (Table 2), ranged from 0.1 to 4.5°C above bottom temperatures recorded at trap #21 (furthest offshore, 9 m depth).

Without continuous temperature recording, it is impossible to know the complete thermal history of this location, but an estimate of temperature increase of 0.5°C during the incubation period does not seem unreasonable. Previous laboratory and field studies (OHRD Report Nos 80-140-K, 87-181-K) have indicated that a 0.5°C increase in temperature over the incubation period would result in hatch advancement of a week, compared to ambient temperature conditions. This would appear to be the case with this larva, as it was not newly hatched, but was similar in size to those collected at Darlington during early spring (April 17-26) sampling. Actual hatch date for this larva would have been a number of days prior to the collection date, possibly as early as April 5-6.

As the outer margins of the emergence traps were not always in complete contact with the substrate, the possibility exists that the captured larvae entered the trap from the surrounding area or, that other larvae which hatched beneath the trap escaped capture. The significance of this depends in part on the motility of newly hatched larvae and their dispersal in the water column.

Personal observations of newly hatched (yolk-sac) larvae indicate that they are negatively buoyant, making only brief forays upward into the water column before tiring and settling back to the bottom. Further laboratory studies of newly hatched larvae indicate that they are closely associated with the bottom (within 10 cm), and tend to remain that way even when disturbed by an approaching benthic sled sampler. Observations of larvae in a flume tank revealed that they could be carried downstream by currents of less than 10 cm/sec. despite their best swimming efforts. Larvae were also observed to rise a few centimeters off bottom during twilight conditions making them more susceptible to capture by a model benthic sled. Collection efficiency however, was directly related to substrate coarseness, with very low efficiency (~5%) on cobble/boulder substrates (OHRD Report No 88-334-K).

Thus, it appears that newly hatched larvae, due to their limited swimming ability, could be very susceptible to displacement alongshore or offshore by lake and/or discharge currents. Their habit of remaining on or very close to the bottom however, would counteract this tendency, especially in areas of coarse substrate (large cobble, boulder). In these areas, current flow would be minimal or non-existent between large particles due to the buffering action of the particles themselves. As substrate along the sampling transects consists mainly of cobble and boulder, it is felt that the two larvae collected in the traps originated from the immediate vicinity of the trap, if not indeed, below it. Similar substrate material has been found to extend at least 1 km eastward from the Pickering "B" discharge, between the 5 and 10 m depth contours (OH D&D Report No 86174).

Finally, entrainment sampling at Pickering during spring, 1988, resulted in the collection of a number of round whitefish larvae as well (OHRD Report No 89-295-K). Sixteen larvae, ranging

in length from 9.7 to 15.0 mm, were collected between March 15 (first day of sampling) and April 27, 1988. This is considerably prior to and after the collection date of larvae during the present study, indicating that a wide range of hatch advancement occurs. In 1988, it was estimated that 110,000 round whitefish larvae were entrained at Pickering NGS "A" and "B". Based on an average fecundity of 5,900 eggs per female, this translates into the reproductive output of 96 spawning females.

Thus, the collection of two round whitefish larvae from the natural substrate in the vicinity of the thermal discharge at Pickering NGS "B" indicates that spawning occurs within or on the fringes of the heated effluent. Models of thermal plume extent and structure, as well as actual field measurements, suggest that sufficient lateral movement of the plume exists that cold acclimated whitefish could spawn under ambient temperature conditions in very close proximity to the thermal plume. Subsequent shifts in wind and/or current direction, would then inundate these eggs with heated discharge waters, causing accelerated development. Their overall rate of development is directly dependent on their thermal exposure. The overall result of this scenario, is the presence of advance hatch larva in the immediate vicinity of the station. This has now been confirmed by two studies.

No estimate of population size can be attained from this study. Samplers employed were not quantitative, but were used to assess presence/absence within the local area. No difference in collection efficiency between the two styles of emergent traps could be determined from this study based on the limited numbers of larval fish collected (1 larva per sampler). Further work should be directed toward assessing the size and extent of the spawning ground, and determining the possible effect that advance hatch may have on the survival of these larvae. The benthic sled sampler, previously employed successfully at Whitby and Darlington, may be suitable for use at Pickering NGS as well.

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APPENDIX 1

LOCATION AND DEPTH OF LARVAL EMERGENCE TRAPS
PICKERING NGS, 1989

TRAP NUMBER	LOCATION* (LAT/LONG)	DEPTH (METERS)	INSTALLATION DATE	TRAP NUMBER	LOCATION* (LAT/LONG)	DEPTH (METERS)	INSTALLATION DATE
1	43 48.35 79 03.53	4.0	MARCH 13	16	43 48.07 79 03.38	6.2	MARCH 13
2	43 48.33 79 03.52	4.0	MARCH 13	17	43 48.05 79 03.37	6.5	MARCH 2
3	43 48.31 79 03.51	4.0	MARCH 13	18	43 48.04 79 03.36	6.5	MARCH 13
4	43 48.29 79 03.50	4.0	MARCH 13	19	43 48.02 79 03.35	7.5	MARCH 13
5	43 48.27 79 03.49	4.5	MARCH 13	20	43 48.00 79 03.34	8.5	MARCH 13
6	43 48.26 79 03.48	5.0	MARCH 13	21	43 47.98 79 03.33	9.0	MARCH 13
7	43 48.24 79 03.47	5.0	MARCH 13	22	43 48.24 79 03.48	5.0	MARCH 20
8	43 48.22 79 03.46	4.7	MARCH 13	23	43 48.23 79 03.49	5.0	MARCH 20
9	43 48.20 79 03.45	4.5	MARCH 13	24	43 48.24 79 03.46	5.0	MARCH 20
10	43 48.18 79 03.44	4.0	MARCH 13	25	43 48.24 79 03.45	5.0	MARCH 20
11	43 48.17 79 03.43	4.0	MARCH 13	26	43 48.10 79 03.42	5.0	MARCH 20
12	43 48.15 79 03.42	4.0	MARCH 13	27	43 48.10 79 03.41	5.0	MARCH 20
13	43 48.13 79 03.41	4.5	MARCH 13	28	43 48.11 79 03.39	5.0	MARCH 20
14	43 48.11 79 03.40	5.0	MARCH 13	29	43 48.11 79 03.38	5.0	MARCH 20
15	43 48.09 79 03.39	5.7	MARCH 13				

* LATITUDE/LONGITUDE SHOWN AS DEGREES, MINUTES AND 100TH OF MINUTE

APPENDIX 2

EMERGENT TRAP SAMPLING SCHEDULE AND RESULTS

TRAP NUMBER	MARCH 17	MARCH 22	MARCH 31	APRIL 5	APRIL 7	APRIL 11	APRIL 17	APRIL 21	APRIL 26	MAY 2	
1				-						SCULPIN	
2				-						SCULPIN	
3				-							
4	SCULPIN		SCULPIN	-			NS				
5			RWF,LOGPERCH	-			SCULPIN				
6			2 SCULPIN	-				SCULPIN			
7			SCULPIN	-			NS	NS	NS	NS	
8			NS	-		SCULPIN		2 SCULPIN		NS	
9	NS	2 SCULPIN		-							
10	NS			-						SCULPIN	
11	SCULPIN		NS	-	NS	NS	NS	NS	NS	NS	
12			SCULPIN	-	2 SCULPIN		3 SCULPIN		SCULPIN	SCULPIN	
13			SCULPIN		SCULPIN	3 SCULPIN	SCULPIN	SCULPIN	SCULPIN		
14						SCULPIN	SCULPIN	2 SCULPIN	SCULPIN		
15		SCULPIN	SCULPIN	2 SCULPIN			5 SCULPIN	SCULPIN	SCULPIN	2 SCULPIN	
16		3 SCULPIN	SCULPIN			2 SCULPIN	SCULPIN	2 SCULPIN	SCULPIN	2 SCULPIN	
17				SCULPIN		SCULPIN	SCULPIN	2 SCULPIN	SCULPIN	SCULPIN	
18				SCULPIN		2 SCULPIN		2 SCULPIN	2 SCULPIN		
19			2 SCULPIN			SCULPIN	2 SCULPIN	6 SCULPIN	SCULPIN	3 SCULPIN	
20	NS	SCULPIN				SCULPIN			SCULPIN	SCULPIN	
21		SCULPIN	4 SCULPIN			SCULPIN					
22	-		3 SCULPIN	-	SCULPIN			NS	NS	NS	
23	-		SCULPIN	-			NS	NS	NS	NS	
24	-			-							
25	-			-					SCULPIN		
26	-			-		SCULPIN	SCULPIN	NS	NS	NS	NS
27	-	SCULPIN	SCULPIN	-	4 SCULPIN		2 SCULPIN	SCULPIN	2 SCULPIN		
28	-			-			SCULPIN				
29	-			-		RWF	SCULPIN		SCULPIN		

NS = NO SAMPLE, TRAP MISSING OR SAMPLE LOST ON RETRIEVAL

- = TRAP NOT SET OR NOT SERVICED (TOO ROUGH)

APPENDIX 3

BOTTOM SUBSTRATE PRESENT AT EMERGENT TRAPS
PICKERING NGS, 1989

TRAP NUMBER	PERCENTAGE BOULDER	PERCENTAGE COBBLE	PERCENTAGE GRAVEL	PERCENTAGE SAND	COMMENTS
1		5		95	RIPPLED SAND WITH OCCASIONAL COBBLE
2	35	65			100% CLADOPHORA COVER ON ROCKS
3	35	65			100% CLADOPHORA COVER ON ROCKS
4	25	65	10		100% CLADOPHORA COVER ON ROCKS
5	35	60	5		CLADOPHORA COVER, BOULDERS TO 75 CM.
6	20	75	5		CLADOPHORA COVER, BOULDERS TO 75 CM.
7					MISSING
8	40	50	10		CLADOPHORA COVER, BOULDERS TO 75 CM.
9	35	60	5		CLADOPHORA COVER, BOULDERS TO 75 CM.
10	35	60	5		CLADOPHORA COVER, BOULDERS TO 75 CM.
11					MISSING
12	15	25		60	CLADOPHORA COVERING ON ROCKS
13	25	40		35	CLADOPHORA COVERING ON ROCKS
14	15	40		45	CLADOPHORA COVERING ON ROCKS
15	10	35	25	30	CLADOPHORA COVERING ON ROCKS
16	15	40	45		CLADOPHORA COVERING ON ROCKS
17	20	65	15		CLADOPHORA COVERING ON ROCKS
18	15	85			CLADOPHORA COVERING ON ROCKS
19	25	75			CLADOPHORA COVERING ON ROCKS
20	25	75			CLADOPHORA COVERING ON ROCKS
21	35	50		15	CLADOPHORA COVERING ON ROCKS
22					MISSING
23					MISSING
24		60	40		CLADOPHORA COVERING ON ROCKS
25	25	65	10		CLADOPHORA COVERING ON ROCKS
26					MISSING
27	10	30	60		CLADOPHORA COVERING ON ROCKS
28	80	15	5		BOULDERS TO 1 M., ALGAL COVERING
29	80	20			BOULDERS TO 1 M., ALGAL COVERING

- = NO SAMPLE